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(54) Brake system for a motor vehicle

(57) A brake system for a motor vehicle has at each wheel an electromechanical wheel brake actuator 4 mounted on the caliper 5 of the wheel, which wheel brake actuator includes an axially movable spindle 24 driven by an electric motor 20. The motor rotor is constructed as a spindle nut 22 of a spindle gear with rotor magnets 23 fitted thereto, and the spindle gear, which may be a planetary roller gearing, a spherical spindle drive or a trapezoidal threaded drive, converts its rotary movement into axial movement of the spindle 24. Lever mechanism 25 multiplies the axial force of the spindle. Control electronics 8 may be integrated into the actuator housing. The spindle may be fitted to the rotor so that the nut moves axially. When current to the motor is terminated with the brake applied, it will remain applied.

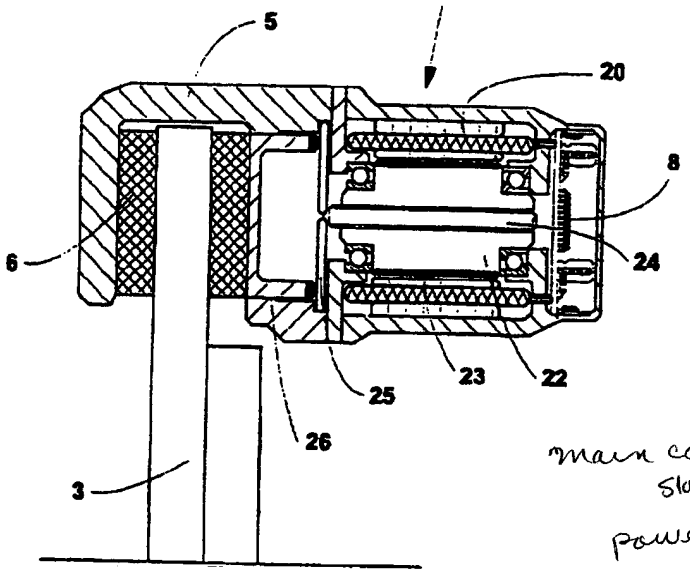

FIG 2

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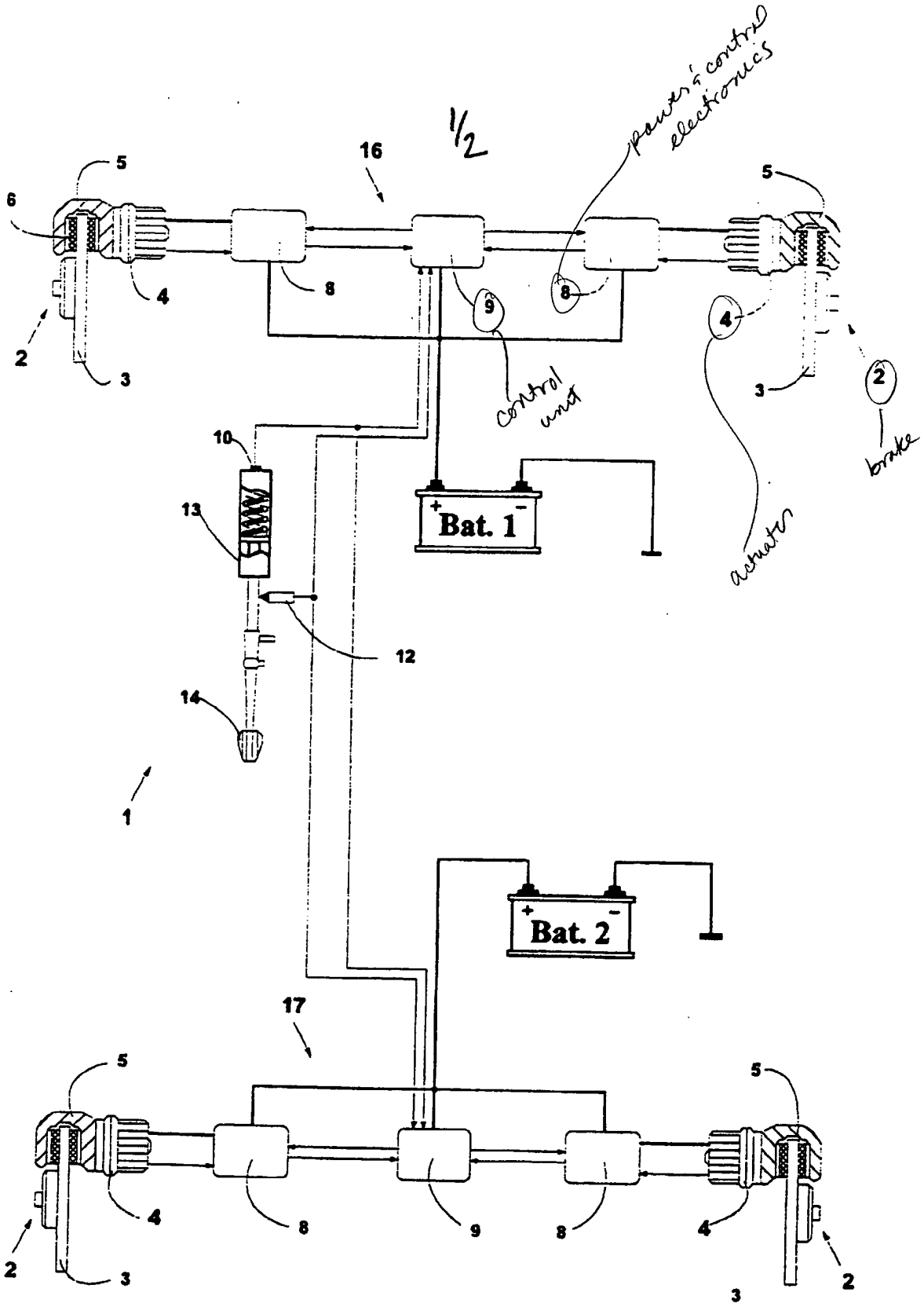
power & control electronics
16
5
6
4
8
2
3
9
control unit
10
13
Bat. 1
12
14
1
actuator
brake
Bat. 2
17

FIG 1

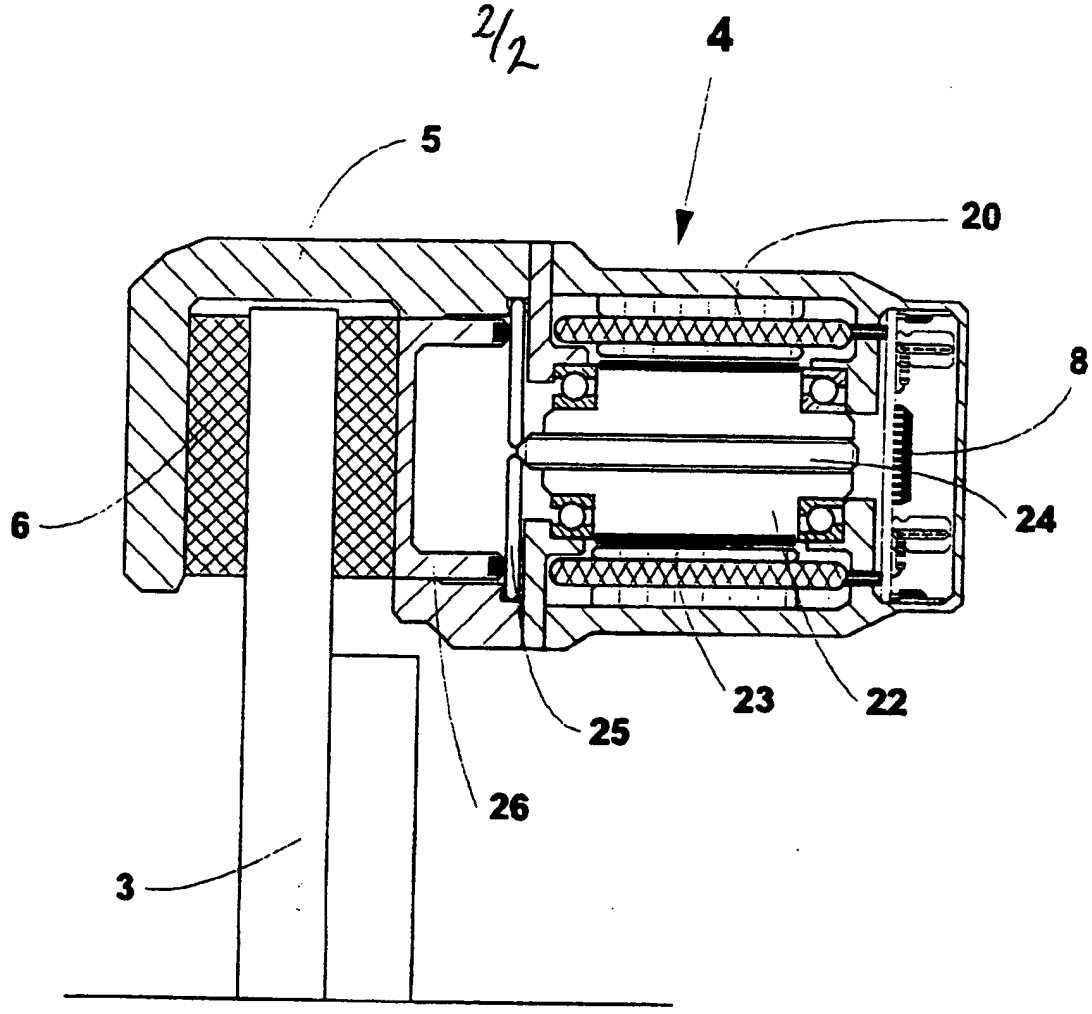

FIG 2

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BRAKE SYSTEM FOR A MOTOR VEHICLE

The invention relates to a brake system for a motor vehicle.

The increasing demands made today on a modern brake system in motor vehicles - for example antilocking devices, driving stability controls, drive slip controls or traction controls - make wheel-selective brake intervention necessary. This has hitherto been realized with conventional brake systems which are extended by hydraulic pumps and electromagnetic valves, as shown in DE-C 29 54 162. However, this approach gives rise to oscillation problems in the hydraulic lines and to a difficult activation of the pressure modulation units, i.e. the electromagnetic valves. The control quality of the brake pressure is also limited in view of the characteristics of the electromagnetic valves, which are intensely non-linear two-point elements. Furthermore, such brake systems require considerable expenditure during assembly in the motor vehicle, in that the brake lines must be laid and connected, the brake system must be filled with brake fluid and ventilated and the system must undergo a seal test. Also during operation a not inconsiderable maintenance expenditure results, in particular with regard to the regular renewal of the brake fluid and its disposal such that it is harmless to the environment.

At the moment all known manufacturers still equip their vehicles with conventional brake systems. Wheel-selective brake intervention is undertaken by means of hydraulic pumps and electromagnetic valves while accepting the disadvantages mentioned above. For a smooth build-up of brake pressure - for example with cruise controller and longitudinal control devices - some manufacturers use electronically controlled vacuum power brakes. In order to suppress the oscillation

problems and the associated development of noise, proportional valves and accumulators can be used, although the proportional valves in particular increase the price of the brake system. The disadvantages associated with the hydraulic fluid are not removed in this way.

A brake system of this kind is shown in DE 195 11 287 A1 and has an electromechanically operated disc brake with a floating calliper and an actuation unit (or brake actuator) fastened to this calliper. The brake actuator comprises an electric motor which by way of a reduction gearing axially displaces a threaded spindle and in this way presses brake linings in pairs against a brake disc. The reduction gearing is designed as a roller threaded drive in the form of a planetary gearing, the rotor of the motor being fastened to a threaded nut which forms the ring gear of the planetary gearing. The planetary wheels are constructed as longitudinal threaded rollers. A reduction gearing of this kind is costly to manufacture.

The invention seeks to create a brake system which can be supplied and assembled for each wheel of the motor vehicle as a finished part and is relatively less expensive to construct and maintain.

According to the present invention, there is provided a brake system comprising an electromechanical wheel brake actuator, including an electric motor, arranged such that, in use, it is actuable to apply a braking force to a wheel.

The invention has the advantage that only electrical supply and control lines must be connected to the brake actuator on the wheel calliper, which brake actuator is supplied as a constructional unit. The brake system allows a continuous control of the braking force at each wheel of the vehicle, from the

base brake function by way of antilocking devices to driving stability controls and electronically controlled brake support. During emergency brakings all requirements made of a modern brake system can be realized without additional expenditure in terms of hardware. Through the omission of the hydraulic fluid the expenditure on maintenance is reduced and compatibility with the environment is improved.

Advantageous developments of the invention are set out in the subclaims.

Although the invention is described with reference to a disc brake system, it is apparent that the invention could be used with another type of brake system.

For a better understanding of the invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a diagrammatic representation of a brake system in accordance with the invention.

Figure 2 shows a sectional representation of a wheel brake actuator used in the brake system according to Figure 1.

Figure 1 shows a brake system 1 for a motor vehicle with four wheels (which is not shown in more detail here). The brake system 1 includes four brakes 2, each of which includes a brake disc 3 and a wheel brake actuator 4 - also called actuator in the following. The wheel brake actuators 4 are integrated into a respective associated calliper 5, i.e. combined therewith to form a constructional unit. The calliper 5 is constructed as a floating calliper. A braking torque is exerted on the brake disc 3 by way of brake linings 6 upon actuation of the wheel brake actuator 4.

Each wheel brake actuator 4 has power and control electronics 8 which are supplied by an associated

control unit 9 with control signals, for example for the desired torque of a wheel brake actuator motor still to be described, and transfer to the control unit 9 check-back variables, for example of the actual torque of the actuator motor.

The power and control electronics 8 likewise receive from the wheel brake actuator 4 check-back variables, for example of the motor speed or the motor angle of rotation or of the contact pressure of the brake linings.

The desired variables for each wheel brake actuator are determined by the control unit 9 from measured variables which are supplied by various sensors, for example a force sensor 10 and a path sensor 12, with which a pedal power simulator 13 is provided which is actuated by the brake pedal 14 of the motor vehicle. The pedal power simulator 13 converts the movement of the brake pedal 14, i.e. the power exerted by the driver as usual, and the pedal path into electric signals which are supplied to the control unit 9 and represent desired values for the brakes 2, in particular for the vehicle deceleration and the torque or braking torque to be applied to the brake discs. To calculate the desired values during an intervention by antilocking or driving stability controls, the control unit 9 evaluates additional sensor signals, for example of the transverse acceleration or the yaw angle speed and the wheel speeds.

The brake system 1 visible in Figure 1 has two brake circuits 16 and 17 which are divided between the front axle and the rear axle. An equally possible diagonal brake circuit division differs from this only by an altered allocation of the wheel brake units to the control units and power supplies. Each brake circuit 16, 17 has its own control unit 9 and its own power supply in the form of a battery Bat. 1 and Bat.

2. The power supplies and the control units can in this respect each be accommodated in a housing, but must then be functionally separated from each other.

Supply lines are drawn in bold in Figure 1 and are not provided with arrows. Control lines are not drawn in bold and are provided with arrows corresponding to the signal flow direction.

The two control units 9 operating independently of each other can communicate with each other by way of a bidirectional signal line and in this way the failure of a brake circuit 16 or 17 in the respective other brake circuit can be detected, and possibly suitable emergency measures can be taken. The brake system can also be extended by a third control unit - not shown here - which monitors the two brake circuit control units as supervisor.

The brake actuator 4 (Figure 2) mounted directly on the calliper as already mentioned, is driven by a commutatorless electric motor 20, which is designed, for example, as an asynchronous machine, synchronous machine or electronically commutated direct current motor. In the exemplary embodiment shown, the control electronics 8 for the electric motor 20 are integrated directly into the housing of the wheel brake actuator 4, but they can also be accommodated in a separate housing if the use of additional lines is acceptable.

A spindle nut 22 of a spindle gear forms the rotor of the electric motor 20, the spindle gear being designed, for example, as a planetary roller gearing, spherical spindle drive, trapezoidal threaded drive or similar. Such spindle gears are known in themselves (for example a one-part threaded nut RGTB of INA linear technology oHG) and all details are therefore not shown. Several rotor magnets 23 are fitted to the spindle nut 22 of the spindle gear. The rotational movement of the rotor is converted by the spindle gear

into a movement of translation of a spindle 24. It is clear that alternatively, the rotor might be fitted to the spindle in order to cause linear motion of the spindle nut in response to the rotation of the rotor. Other arrangements for converting rotational movement or torque of the rotor to linear movement or torque may be used.

The axial force of the spindle 24 is multiplied by a mechanical gear 25 in the form of a lever mechanism and is transmitted to a wheel brake cylinder piston 26 which presses the brake linings 6 against the brake disc 3 and thus generates a brake torque on the brake disc.

With the wheel brake actuator 4 described above, it is possible to continuously adjust the brake torque at the respective wheel by way of the drive torque of the associated actuator motor 20. The vehicle manufacturer can obtain the entire brake device for a wheel as a finished part and now only needs to connect power supply and control lines. The electronics necessary to control the wheel brake actuator can be accommodated on the actuator itself. With the aid of the mechanical gear the actuator reduces the power requirements of the motor torque and also the structural size and the weight of the wheel brake actuator.

Since no more hydraulic fluid is required, the maintenance expenditure is reduced and the compatibility of the brake system 1 with the environment is improved. In an older application DE 19529664.8 (our reference GR 95P1763 DE) an analogously assembled wheel brake actuator is shown which in place of a mechanical gear has a hydraulic gear.

Basically the actuator unit comprising power and control unit, electric motor and spindle bearing unit

can be used independently of the type of gear (hydraulically or mechanically) if it is only ensured that the same gear ratios exist. The resulting reduction of the wide variety of types reduces the costs for the manufacture and the expenditure for storing the brakes.

Because of the friction losses of the spindle gear 22, 24 and the gear step 25, after actuation of the wheel brake actuator the spindle 24 does not automatically return to the position of rest, but has to be returned by passing current through the electric motor 20. This characteristic can be used for a hand brake function: the actuator is actuated by the control unit until a specified tightening force on the calliper is reached, and thereafter the brake system is disconnected. Because of the residual catch the brake remains in the position reached, even if the electric motor 20 has no current pass through it. The legal requirements made of the retention force of this hand brake function can be maintained by suitable selection of the friction parameters.

CLAIMS

1. A brake system comprising an electromechanical wheel brake actuator, including an electric motor, arranged such that, in use, it is actuable to apply a braking force to a wheel.

2. A brake system according to claim 1, wherein the electromechanical wheel brake actuator is mounted on a calliper of a wheel of a motor vehicle and arranged such that, in use, the wheel brake cylinder piston presses brake linings against a brake disc of the wheel so as to produce a brake torque at the brake disc.

3. A brake system according to claim 1 or 2, further comprising means to convert the rotary torque of the electric motor to linear force.

4. A brake system according to claim 3, further comprising a mechanical gear for multiplying the linear force generated by the conversion means and for transmitting the force to the wheel.

5. A brake system according to claim 3 or 4, wherein said motion converting means is a spindle gear.

6. A brake system according to claim 4, wherein the rotor of the electric motor is constructed as a spindle nut of a spindle gear for converting the rotary movement of the rotor into a linear movement of the spindle.

7. A brake system according to claim 6, wherein rotor magnets of the electric motor are fitted to the spindle nut.

8. A brake system according to claim 5, 6 or 7, wherein the wheel brake actuator with spindle gear is used as a locking brake.

9. A brake system according to one of the preceding claims, wherein control electronics are integrated into the housing of the wheel brake actuator.

10. A brake system substantially as herein described, with reference to the accompanying drawings.

11. A motor vehicle having a brake system in accordance with any preceding claim.

Amendments to the claims have been filed as follows

CLAIMS

1. A brake system comprising an electromechanical wheel brake actuator, including an electric motor, means to convert the rotary torque of the electric motor to linear force, and a mechanical gear for multiplying the linear force generated by the conversion means and for transmitting the force to the wheel.

2. A brake system according to claim 1, wherein the electromechanical wheel brake actuator is mounted on a calliper of a wheel of a motor vehicle and arranged such that, in use, the wheel brake cylinder piston presses brake linings against a brake disc of the wheel so as to produce a brake torque at the brake disc.

3. A brake system according to claim 1 or 2, wherein said motion converting means is a spindle gear.

4. A brake system according to claim 1, 2 or 3, wherein the rotor of the electric motor is constructed as a spindle nut of a spindle gear for converting the rotary movement of the rotor into a linear movement of the spindle.

5. A brake system according to claim 4, wherein rotor magnets of the electric motor are fitted to the spindle nut.

6. A brake system according to claim 3, 4 or 5, wherein the wheel brake actuator with spindle gear is used as a locking brake.

7. A brake system according to one of the preceding claims, wherein control electronics are integrated into the housing of the wheel brake actuator.

8. A brake system substantially as herein described, with reference to the accompanying drawings.

9. A motor vehicle having a brake system in accordance with any preceding claim.

The Patent Office

Application No:	GB 9707746.5	**Examiner:**	Peter Squire
Claims searched:	1-11	**Date of search:**	19 June 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2E EQ

Int Cl (Ed.6): F16D 63/00 65/16, 34 B60T 13/74

Other: Online:EDOC,WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2156021 A	(Teves) see Figure 2	1-3, 5, 11
X	WO 96/03301 A1	(ITT Automotive Europe GmbH) see Figures	1-3, 5-7, 11
X	US 5107967	(Honda) see e.g.col.5 line 46 - col.6 line 53	1-3, 5, 8, 9, 11
X	US 4804073	(Allied-Signal) see e.g.col.3 lines 15-18 and description relating to Figure 6	1-3, 5, 8, 11
X	US 4784244	(Bendix) see whole document	1-3, 5, 11

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.